

jc490 U.S. PTO
03/10/00

SWABEY OGILVY RENAULT

S.E.N.C.

PATENT AND TRADE MARK AGENTS

The U.S. Assistant Commissioner for
Patent & Trademark
The U.S. Patent & Trademark Office
Washington, D.C. 20231
U.S.A.

Montréal, March 10, 2000

New Continuation Application of a U.S. Patent Application

Continuation of U.S. serial no
08/922,026 - filed September 2, 1997
Agent's Reference: 13468-1"US"-1 JA/IC

Sir:

Enclosed herewith for filing with the USPTO is a continuation patent application. The inventor is Canadian and the particulars are as follows:

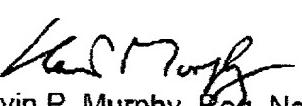
Boiko VODANOVIC whose full post office address is 86 Midland Avenue, Beaconsfield, Quebec, Canada, H9W 4P1.

The following documents are enclosed:

Specification containing:
 description – pages 1 to 12
 claims 1 to 15 - pages 13 to 15
 abstract – page 16
 drawings - 8 sheets of informal drawings
 unsigned Declaration and Power of Attorney

We look forward to receiving the official filing certificate and your notice to file missing parts in due course.

Respectfully submitted,


Kevin P. Murphy, Reg. No. 26,674

Encls.: Specification
 unsigned Declaration and Power of Attorney
 informal Drawings

PC675 U.S. PTO
03/10/00

ROBERT MITCHELL
 GUY J. HOULE
 PAUL MARCOUX
 KEVIN P. MURPHY
 JOHN D. MILLER
 ROBERT CARRIÈRE
 MIGHEJ. SOPHIA
 FRANCE CÔTE
 CELINE TREMBLAY
 MAX R. WOOD
 JAMES ANGLEHART
 PAUL J. FIELD
 PATRICIA SEGUIN
 WAYNE YAN
 FRANÇOIS NADBAU
 KENT DANIELS

JOAN CLARK, Q.C.
 C. ROSS CARSON
 MALCOLM E. MCLEOD
 J. NELSON LANDAY
 DANIEL I. LACK
 PATRICK E. KIERANS
 CLAUDE BRUNET
 TERRANCE J. McMANUS
 JOHANNE GAUTHIER
 DANIELLE BOUTET
 KENNETH B. SHARPE
 JUDITH ROBINSON
 DANIEL S. DRAPEAU
 GEORGE R. LOCKE
 NICOLAS SAPT
 BRIAN DALEY
 LEIGH D. CRESTOHL
 JOANNÉ CHRIQUI
 BENOÎT CLERMONT
 LEANNE SOUQUET

Administrator
JAMES A. PRASER

ALAN SWABEY [1909-1990]
MELVIN SHER [1935-1994]

A FIRM IN WHICH SWABEY, MITCHELL,
HOULE, MARCOUX & SHER AND
THE LAW FIRM OGILVY RENAULT
ARE PARTNERS

- 1 -

CCD IMAGING DEVICE AND METHOD FOR HIGH SPEED PROFILING

The present application is a continuation-in-part of US patent application 08/922,026 filed September 2, 1997.

5 FIELD OF THE INVENTION

The present invention relates to 2D image sensors and, more particularly, to an interline or frame transfer type image sensing method and apparatus used for readout of a CCD array image sensor at fast frame rates useful for high speed object profiling and surface geometry measurements.

10

BACKGROUND OF THE INVENTION

A typical solid-state imaging sensor device is composed of a charge-integrating photosites arranged in rows and columns. Each photosite responds to incident radiation by providing an electrical signal corresponding to 15 one pixel of frame information. In the interline transfer type, charge is transferred out at once into a parallel structure of vertical shift registers. First, a charge pattern is accumulated at integration sites during image acquisition period, then the charge pattern is transferred into storage columns, also known as vertical shift registers. The transferred charges are then shifted one line at a 20 time, into a horizontal readout register from which a line-by-line 2D video output signal is taken. This is known in the prior art and commonly allows taking pictures at a frame rate of about 30 frames per second.

Also known in the prior art is the use of such CCD cameras in acquiring profiles of objects for surface geometry inspection and 25 measurements of relatively small objects. This is done by illuminating the surface of the object by an incident high energy light plane usually coming from a laser, and capturing the reflected light on the CCD image sensor array. Then, the acquired profile of the object can be isolated for shape or surface geometry inspection of the object. A limitation of the known technique comes from the 30 fact that when many surface portions have to be inspected in a short period of time (e.g. on a assembly-line) the standard frame rate of the CCDs is no longer sufficient, because the known method allows inspecting at most one profile per

SEARCHED INDEXED
SERIALIZED FILED

frame period per CCD camera. Various improvements to the known technique are disclosed in US patents 4,162,126 to Nakayama et al., 5,083,867 to David Burk and 5,177,556 to Marc Rioux.

There are also other prior US patents that allow improvements

5 concerning the frame rate being read from a CCD sensor. This is done by formatting the area sensor into blocks of photosites so that fewer sectors have to be read (e.g. US patent 4,322,752 to James Bixby) or by adding adjacent pixel charges to improve at the same time the acquisition frame rate and the dynamic range of the image (e.g. US patent 5,420,629 to Takashi Watanabe).

10 None of these prior patents allow a standard interline transfer CCD to be used having an improvement of a factor greater than 4 over the standard read rate and, when there is improvement, this is done at the expense of detail or quality of the captured image.

15 SUMMARY OF THE INVENTION

In accordance with the present invention, method and apparatus are provided for reading out information from a solid-state image sensor in a fraction of the time that would be required using a known interline transfer CCD sensor for surface geometry inspection or object profiling. Further, according with the present invention, improvement of a factor of 50 is possible over the standard read rate of a CCD area sensor for such particular applications.

According to a broad aspect of the present invention, the charge transfer signal TR, which controls the transfer of the accumulated electrical charges from CCD's photosites into the vertical shift register is triggered more than once per frame period (e.g. n times per frame period, where n is a value greater than one, while in the prior art method n was always less or equal to one), and this results in a conventionally unwanted overlapped image composed of more than one profile line. Using a filter tuned to the light source frequency or other optical means such as masking, only the profile line of the object being illuminated is captured onto the area sensor in the present invention. The only limitation of the present method is that consecutive profile

- 3 -

lines captured during the same frame period do not overlap. In some particular conditions, even overlapped profiles may be isolated by computer calculation.

According to this invention, there is provided a high-speed imaging system which uses an interline transfer charge-coupled device CCD sensor having n horizontal pixel lines, a TR image transfer signal input and a line or vertical transfer signal input. The CCD sensor is arranged to receive profile line images having an essentially dark background and it includes an image acquisition control circuit which comprises first, a vertical transfer signal generator means for generating a signal for the vertical transfer input having a frequency f_L of n times per frame period and second, a TR signal generator means for generating an output signal TR having a frequency f_{TR} , for the TR image transfer signal input, wherein the f_{TR} frequency is greater than $1/n * f_L$, in order to capture more than one profile image per frame period.

It is accordingly an object of this invention to provide a method of driving an interline transfer type CCD sensor is disclosed, where the CCD sensor has n horizontal pixel lines, a TR image transfer signal input and a line or vertical transfer signal input. The mentioned method comprises the essential steps of (1) generating an output signal of frequency f_L of n times per frame period for the vertical transfer signal input in order to transfer CCD vertical shift register charges, one line at a time, into a horizontal shift register and (2), generating an output signal TR having a frequency f_{TR} , for the TR image transfer signal input, wherein the f_{TR} frequency is greater than $1/n * f_L$, in order to capture more than one profile image per frame period.

The invention further provides a method of inspecting an object using high speed profiling comprising: projecting light in a plane onto the object to create a profile line on the object; arranging a camera system including an interline transfer charge-coupled device (CCD) sensor to obtain a profile line image of the object, wherein the profile line image appears within a substantially dark background and extends substantially along a horizontal direction of the CCD sensor, the CCD sensor having horizontal lines that are vertically transferred to output its image data; and controlling the CCD sensor's image transfer rate to capture more than one profile image per frame period.

RECORDED - DEPT. OF STATE

- 4 -

Preferably, many profile line images are captured per frame period. The number of images captured per frame period depends on the vertical dimensions of the CCD sensor being used, the required exposure or image acquisition time, and rate of variation or change in the profile line shape.

5 According to another aspect of the invention, there is provided a high speed profiling imaging system and method using a frame transfer charge-coupled device (CCD) sensor. The sensor has n horizontal pixel lines in an exposed image area, a protected area, a line shift transfer mechanism for transferring lines from the exposed area into the protected area, and a read-out
10 mechanism for reading out image data from the protected area. The CCD sensor is arranged to receive substantially horizontal profile line images in an essentially dark background. According to the invention, the system includes an image acquisition control circuit comprising a frame transfer controller generating a shift control signal for the line shift transfer mechanism to cause a
15 rapid transfer of m lines from the exposed area into the protected area, and for pausing the generating of the shift control signal to allow for image acquisition of the profile line image, wherein m is less than the n horizontal pixel lines, the frame transfer controller causing the transfer of m to provide more than one profile image per frame period, and a read-out controller generating a read-out
20 shift control signal for the read-out mechanism, the read-out controller reading out m lines during the pausing and then pausing until the transfer of the m lines from the image area is completed by the frame transfer controller.

Preferably, the frame transfer controller further controls a light source to turn it off during the transfer of m lines to the protected area and to turn it on
25 during the image acquisition pausing. Also, a user interface device may be connected to the frame transfer controller and the read-out controller for selecting a value of m and a time period for the image acquisition pausing. An automatic adjusting mechanism may also be connected to the frame transfer controller and the read-out controller for selecting a value of m and a time
30 period for the image acquisition pausing depending on an input signal representing a minimum spacing between two of the profile line images.

DOCUMENT STAMPED - DEPO

- 5 -

BRIEF DESCRIPTION OF THE DRAWINGS

This invention may be better understood and its objects and advantages will become apparent to those skilled in art by reference to the accompanying drawings, in which:

5 FIG. 1 shows a typical prior art apparatus arrangement for surface profiling measuring using a light plane projected on the object being profiled and captures throughout a lens plane on the CCD plane;

FIG. 2 shows an interline transfer type CCD array as known in the prior art;

10 FIG. 3 shows the interline transfer type CCD array of the improved technique presented by the present invention wherein the TR control signal has been triggered more than once per frame period so multiple profile lines have been acquired onto the CCD sensor;

15 FIG. 4 illustrates an example of image where consecutive profiles of spherical object (a ball) originally overlap but which are separated using computerized image processing;

FIG. 5 shows a block diagram representing the complete electronic circuit comprising the main devices employed in order to control the CCD camera and to perform video processing;

20 FIG. 6 shows the camera controller and the CCD camera of the present invention, where the f_{TR} frequency is controlled by the user via the user interface;

25 FIG. 7 shows the camera controller and the CCD camera of the present invention, where automatic frequency regulator is included for f_{TR} frequency; and

FIG. 8 shows a frame transfer type CCD array array of the improved technique presented by the present invention wherein the frame transfer CCD exposes the image and then clocks the entire exposed image area shifting it at high speed line by line into the protected area.

30

DESCRIPTION OF THE PREFERRED EMBODIMENTS

While the general principle of operation of an interline transfer type CCD area sensor has been described above, it is helpful for purpose of understanding the present invention to re-examine the general mechanism of a charge-coupled device camera and particularly the method employed in such an apparatus in order to transfer the accumulated charges from the photosites into the vertical shift register.

As explained before, an interline transfer CCD image sensor as the one shown in FIG. 2 comprises light-sensitive elements or photosites designated by 10, which are arranged in rows and columns forming a matrix form. Each photosite 10 performs a transformation of the incident light into electrical charges which are then accumulated inside the said photosites. The output of each of these cells connects to its corresponding cell of one or more vertical shift registers 12 which are hidden from light exposition by a shield and which are used for temporary storage of the electrical charges representing the acquired image, before forming a final video line. The horizontal transfer of the photosites accumulated electrical charges into the vertical shift register 12, is controlled by an electrical signal called TR of frequency fTR, which is triggered at the end of each video sequence in order to start the acquisition of the next frame by transferring the electrical charges from the exposed photosites 10 into the vertical shift register 12.

Following this horizontal transfer, the charges shifted inside the vertical register 12 correspond to the image previously acquired. At the clock signal V of frequency f_L , the vertical shift register charges are downloaded, one line at a time, into the horizontal shift register cells 14, as shown by the vertical arrows at the bottom of FIG. 2. The charges contained in that horizontal register 14 now form a final video line, which is output to an electronic video processing circuit following the horizontal output arrow on the FIG. 2, according to a signal clock H of frequency f_P , and all of the video lines, when shifted sequentially, forms the complete video frame.

As explained before, such a CCD image sensor can also be used for geometry inspection and object profiling and in these particular cases the

final image captured by the CCD camera is composed of a profile line of the observed object.

A typical apparatus arrangement for surface profile measuring is shown in FIG. 1. An high intensity light plane designated by 2, coming from a laser, is projected over the object being inspected and the reflected bright light line 4 resulting from the intersection of the light plane 2 with the object surface is collected via a lens 6 on the CCD sensor array 8. Other optical means such masking, or a filter tuned to the light frequency may be used in order to isolate that bright line from adjacent reflections or from other light coming from other sources which could interfere with the main light line.

In that particular application, the result of using the prior art technique of triggering the TR signal only once per frame is that every image captured on the CCD array sensor contains only a single profile line. The disadvantage of this prior art technique is that when it is used for high speed object profiling, such as on an assembly line, acquiring a single profile per frame is no more sufficient because of the prior art frame acquisition rate which is of only 30 frames per second. In that case, the frame period, which is the time interval required to form a complete image and which corresponds in the prior art technique to the time comprised between two consecutive non-null values of the TR control signal, is about 1/30 of a second, so no more than about 30 objects parts can be inspected during the same second.

The preferred embodiment of the present invention is related to the technique of transferring the electrical charges from the photosites 10 into the vertical shift register 12 of a CCD image sensor. Instead of triggering the transfer control signal TR only once per frame period as in the prior art method, a preferred embodiment of this invention is a technique that permits triggering the TR signal a much greater number of times during the same image composing period. Each time the TR control signal is triggered, the accumulated electrical charges are shifted from the light-sensitive cells 10 into their corresponding vertical shift register cells 12, and added to any prior shifted charges, that got a few vertical pixel lines closer to the horizontal shift register 14 by this time, as shown in FIG. 3. In this way another acquired profile

- 8 -

line image 16 is transferred over the prior acquired profile line image 18, before that prior image 18 has left the vertical shift register 12 as was done in the prior art method. It is important that the CCD camera is configured not to expunge the prior shifted electrical charges from the vertical register cells 12, at the time
5 of the transfer of the new charges from the photosites 10 into the vertical register cells 12. Therefore, the result of the transfer would normally be an unwanted overlapped image. But since, first, the vertical shift register 12 is also downloaded line by line into the horizontal shift register 14 with a frequency f_L , wherein $1/n * f_L$ is less than the TR control signal frequency f_{TR} , as shown by
10 the vertical arrows in FIG. 3, and since, second, the acquired image is a very thin and bright profile line which is substantially horizontal, this profile line will not overlap with the prior captured profile line, because the prior electrical charges corresponding to the prior line will already be moved a few pixel lines closer to the horizontal shift register 14 (or lower, as shown in FIG. 3) by the
15 time the new charges are shifted from the photosites 10 into the vertical shift register cells 12.

For example, when using a CCD area sensor of 1024 pixels wide by 768 pixels high, even if the TR signal is triggered 50 times per frame period which results in 50 bright profile lines on each image of 768 pixels high, that
20 still allows about 15 vertical pixels separation between 2 consecutive profile lines, as shown in FIG. 4, providing that a profile line's width is substantially narrower than 15 pixels. For a frame rate of 30 Hz, the TR signal frequency will be of 1500 Hz which is, for most applications a very fast image acquisition rate. As will be appreciated, the lines are substantially horizontal meaning that any
25 deviations from a horizontal baseline in the profile images result in no image overlap or an acceptable amount of image overlap in the acquired profile line images obtained according to the invention.

The main application of this technique is to capture very bright profile lines on an essentially dark background. In such case, which is used for
30 geometry inspection and object profiling, a photosite charge level of a cell corresponding to a part of the bright profile line, will only change a little or will not change at all during the addition process over the prior shifted charge from

- 9 -

the photo-sensitive cell 10 into the vertical shift register cell 12, since this previously acquired charge corresponds to an upper dark area of the image which corresponds in electrical terms to very low or even to a null electrical charge level (see FIG. 4). This particular condition of operation on a dark
5 background allows easier separation of consecutive bright profile lines which can now be read at a much greater speed than in the prior art.

The present invention provides an improvement over the prior art frame acquisition by up to a factor of 50, depending of the thickness of the acquired image. The limitations of the technique according to the invention are
10 the image accuracy and definition wanted for a particular image, or not overlapping consecutive profiles. In that later case, it is possible that for certain surfaces having general known characteristics, it would even be possible to separate consecutive overlapped profiles using a known surface model and computer calculation. Fig. 4 shows such a situation, where the profiles are
15 obtained by scanning a known diameter ball sitting on a flat surface, and where the round ball profiles have been separated from the flat surface of the floor using algorithms that calculate curvatures from neighboring profile points. Then, knowing the nominal ball diameter it is easy to pair corresponding floor and ball top profiles.

20 In the preferred embodiments of this technique, high-speed, progressive scan, interline transfer, multiple tap CCDs are used such as the TV format CCD having 694 by 496 lines such as the KODAK KAI-0310M camera or the HDTV format 1948 pixels by 1092 lines image sensors such as the KODAK KAI-2090M camera. Other interline transfer CCDs from other
25 manufacturers are suitable as well.

In another embodiment of the present invention, multiple sensors or CCD combinations may be used to either increase speed or acquire a particular geometry of the observed object. For example, putting two CCD cameras one on each side of the laser plane can increase scanning speed and
30 at the same time provide means to avoid some occlusion problems like when mapping two sides of a steep pyramid. Side by side camera combination can increase the scanning width and also preserve vertical resolution.

DEPARTMENT OF STATE

- 10 -

In another embodiment of the present invention, the triggering method can be used to capture other high aspect ratio (width/height) images, which are not profile lines but have a non-negligible thickness, onto the CCD sensor one above the other, under normal lighting conditions, by positioning an optical means such an appropriate slot in the front of the CCD sensor such as only n lines of the CCD array are exposed to the light. In this case, a new exposure can occur after each shift of n lines, by triggering the TR signal, which results in much higher image rate output. This embodiment is useful for high speed event recording.

Another embodiment of the invention relates to the electronic circuit used with the present technique in order to control the TR control signal frequency and allow the capture of as many profile lines as wanted during the same frame period. FIG. 6 shows a block diagram of this preferred embodiment. The user interface block comprises any device which may be used to select the TR signal frequency, in order to control the number of profile lines x that will be captured on the same frame. This numerical value, noted x, may range from 1, which corresponds to the standard read rate of the prior art, to 50 or more, depending of the vertical resolution of the CCD array and of the thickness of the image being acquired. Therewith, the user selection is send into a frequency generator 22, which converts the received user control signal into a signal of particular frequency f_{TR} , greater than the frame rate, that allows the selected number of profile lines x to be captured in the same frame. The said camera controller outputs the vertical clock signal and the horizontal clock signal, having respective frequencies f_V and f_H . Since the TR frequency is greater than the frame rate, the TR signal is triggered more than once per frame period which results in having more than one profile line being captured on the same frame.

Another embodiment of the present invention relates to an automatic means for controlling the TR signal frequency. Instead of having the user to control that frequency in order to get the optimum acquisition rate, this embodiment introduce an image analyzer 30, as shown in FIG. 7, capturing the video image output by the CCD camera, and processing the said image in

RECORDED - INDEXED - SERIALIZED - FILED

- 11 -

order to result a value corresponding to the minimum spacing between two consecutive profile lines. This value is then used to control the TR frequency regulator 32 in order to allow the TR frequency regulator 32 to output the highest TR frequency possible without overlapping profile lines. The video
5 output in the systems shown in Figs. 6 and 7 have a dual output CCD camera, namely two lines of the CCD are output together (Video 1 and Video 2), and thus the image transfer rate is doubled. Such multiple line CCD cameras are known in the art.

Also according to the invention, a frame transfer CCD (Figure 8) can be
10 used. The frame transfer CCD exposes the image and then clocks the entire exposed image area shifting it at high speed line by line into the protected area. The protected or output area has its own clocks to shift the image information line by line into the output register and shift the information out of the output register pixel by pixel.

15 To operate such CCD to achieve the same effect as described for the interline transfer CCD, the CCD should be exposed for m line periods after which the laser (or other illumination source) is preferably turned off and the parallel transfer of m lines is executed. During the exposure time, the read-out circuitry reads out the m lines. The exposure time may be greater than this
20 read-out time, however, for optimum performance, it should be as close as possible. When m is equal the total number of CCD lines n , the above describes the *normal* operation. By selecting m smaller than the total number of lines n , a partial frame transfer will be executed resulting in multiple exposures as with the interline transfer CCD.

25 A disadvantage of using a frame transfer CCD is some smearing, and thus the need to turn off the laser during the parallel transfer to avoid any possible unmanageable smearing. An advantage is higher sensitivity due to larger active area per pixel since no separate shift registers exist.

As in the preferred embodiment, control over the parameters of m and
30 the exposure time can be set by the operator or automatically determined.

Although the invention has been described above with reference to a preferred embodiment and alternative embodiments, it is to be understood that

RECORDED IN U.S. PATENT AND TRADEMARK OFFICE

- 12 -

the above description is intended merely to illustrate the invention and not to limit the scope of the invention as defined in the appended claims.

- 13 -

I claim:

1. A high speed profiling imaging system using a frame transfer charge-coupled device (CCD) sensor having n horizontal pixel lines in an exposed image area, a protected area, a line shift transfer mechanism for transferring lines from said exposed area into said protected area, and a read-out mechanism for reading out image data from said protected area, said CCD sensor being arranged to receive substantially horizontal profile line images in an essentially dark background, said system including an image acquisition control circuit comprising:

a frame transfer controller generating a shift control signal for said line shift transfer mechanism to cause a rapid transfer of m lines from said exposed area into said protected area, and for pausing said generating of said shift control signal to allow for image acquisition of said profile line image, wherein m is less than said n horizontal pixel lines, said frame transfer controller causing said transfer of m to provide more than one profile image per frame period; and

a read-out controller generating a read-out shift control signal for said read-out mechanism, said read-out controller reading out m lines during said pausing and then pausing until said transfer of said m lines from said image area is completed by said frame transfer controller.

2. A high speed profiling imaging system as defined in claim 1, further comprising a light source for projecting light onto an object to create said profile line thereon, said frame transfer controller further controlling said light source to turn it off during said transfer of m lines to said protected area and to turn it on during said image acquisition pausing.

3. A high speed profiling imaging system as defined in claim 2, further comprising a user interface device connected to said frame transfer controller and said read-out controller for selecting a value of m and a time period for said image acquisition pausing.

SEARCHED
SERIALIZED
INDEXED
FILED

- 14 -

4. A high speed profiling imaging system as defined in claim 2, further comprising an automatic adjusting mechanism connected to said frame transfer controller and said read-out controller for selecting a value of m and a time period for said image acquisition pausing depending on an input signal representing a minimum spacing between two of said profile line images.
5. A high speed profiling imaging system as defined in claim 1, further comprising a user interface device connected to said frame transfer controller and said read-out controller for selecting a value of m and a time period for said image acquisition pausing.
6. A high speed profiling imaging system as defined in claim 1, further comprising an automatic adjusting mechanism connected to said frame transfer controller and said read-out controller for selecting a value of m and a time period for said image acquisition pausing depending on an input signal representing a minimum spacing between two of said profile line images.
7. A high speed profiling imaging system as defined in claim 1, wherein a time period for said image acquisition pausing is less than a minimum time required to read-out n lines from said protected area by said read-out mechanism.
8. A high speed profiling imaging system as defined in claim 7, wherein said time period is between 10 to 50 times less than said minimum time required.
9. A high speed profiling imaging system as defined in claim 2, wherein a time period for said image acquisition pausing is less than a minimum time required to read-out n lines from said protected area by said read-out mechanism.

DRAFTED BY GENE COOKE

- 15 -

10. A high speed profiling imaging system as defined in claim 9, wherein said time period is between 10 to 50 times less than said minimum time required.

11. A high speed profiling imaging system as defined in claim 3, wherein said time period for said image acquisition pausing is less than a minimum time required to read-out n lines from said protected area by said read-out mechanism.

12. A high speed profiling imaging system as defined in claim 11, wherein said time period is between 10 to 50 times less than said minimum time required.

13. A high speed profiling imaging system as defined in claim 4, wherein said time period for said image acquisition pausing is less than a minimum time required to read-out n lines from said protected area by said read-out mechanism.

14. A high speed profiling imaging system as defined in claim 13, wherein said time period is between 10 to 50 times less than said minimum time required.

15. A high speed profiling imaging system as defined in claim 1, further comprising an optical means for masking a part of said CCD sensor on which no part of said profile line is to be captured, to eliminate any incident light on the said masked part of said CCD sensor which is not used for image acquisition, in order to improve an accuracy of said profile line images, wherein a shape of said masked portion of the CCD sensor depends of a maximum shape variation of said profile lines being acquired.

- 16 -

ABSTRACT

The present invention provides a method and apparatus for increasing the frame acquisition rate of an interline transfer CCD sensor by triggering the charge transfer signal TR, which controls the shift of the electrical charges from the light-sensitive cells into the vertical shift register, more than once per frame period, so that more than one image is acquired in the same frame, one above the other. The apparatus is used primarily for surface geometry inspection of high-speed moving objects, wherein acquired CCD images are thin, substantially horizontal profile lines.

RECORDED IN COLOR

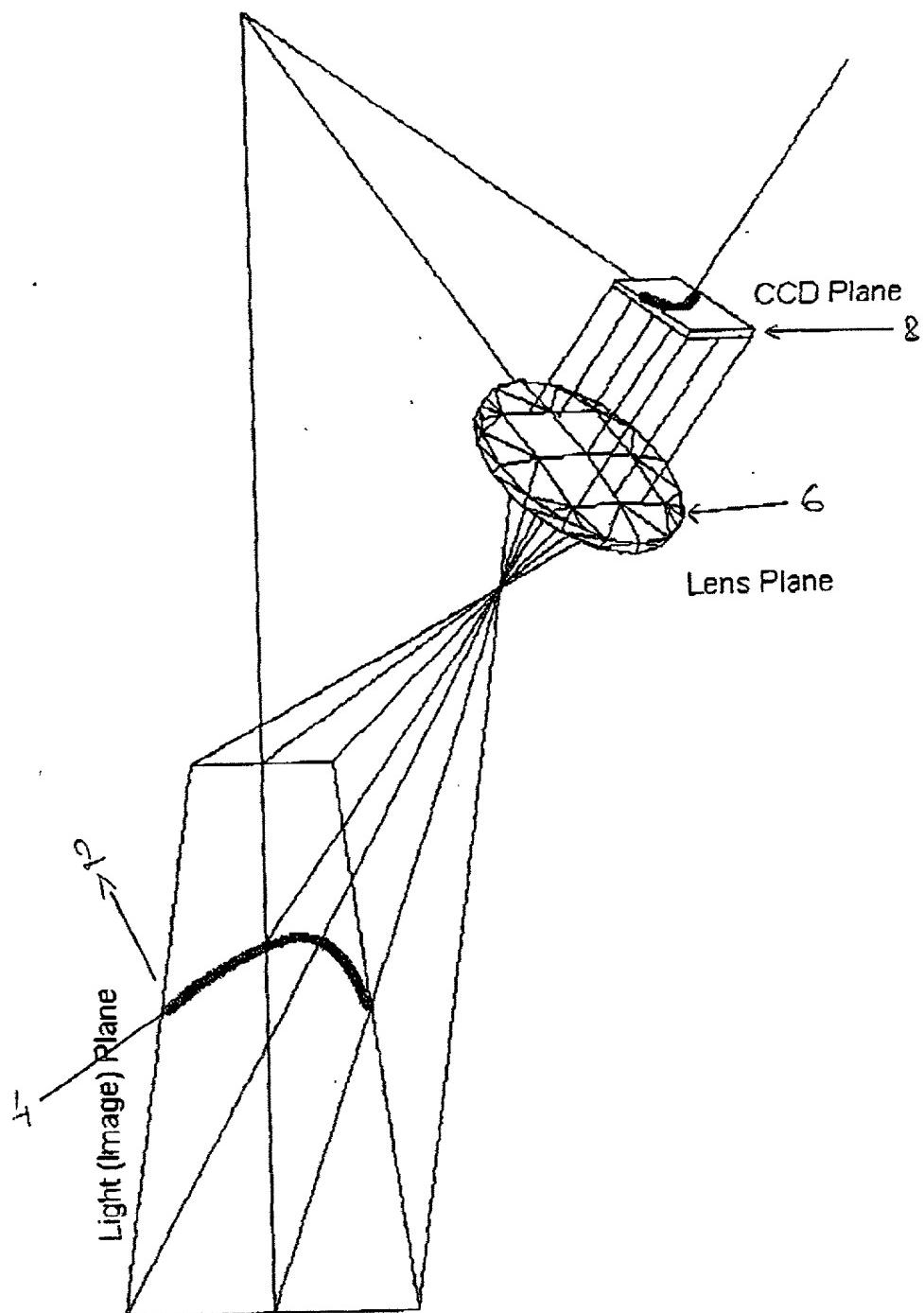


FIGURE 1: Prior art

DRAFT - NOT FOR CITATION

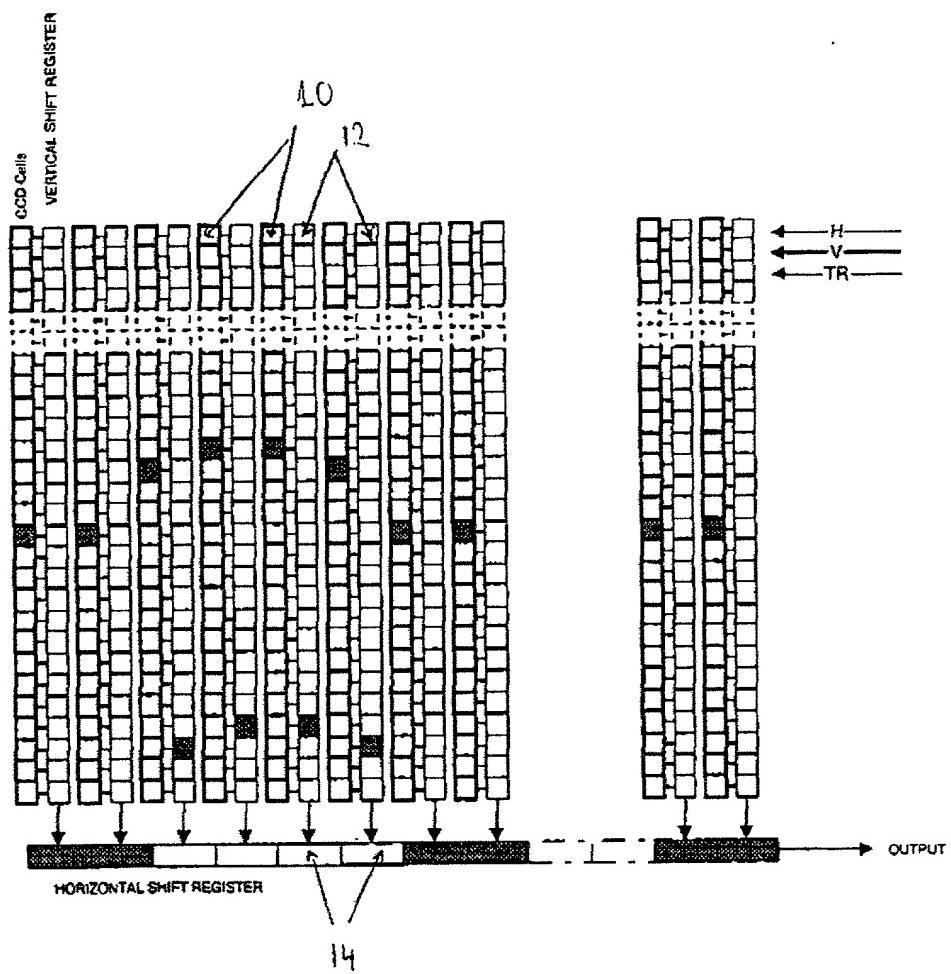


FIGURE 2: Prior art

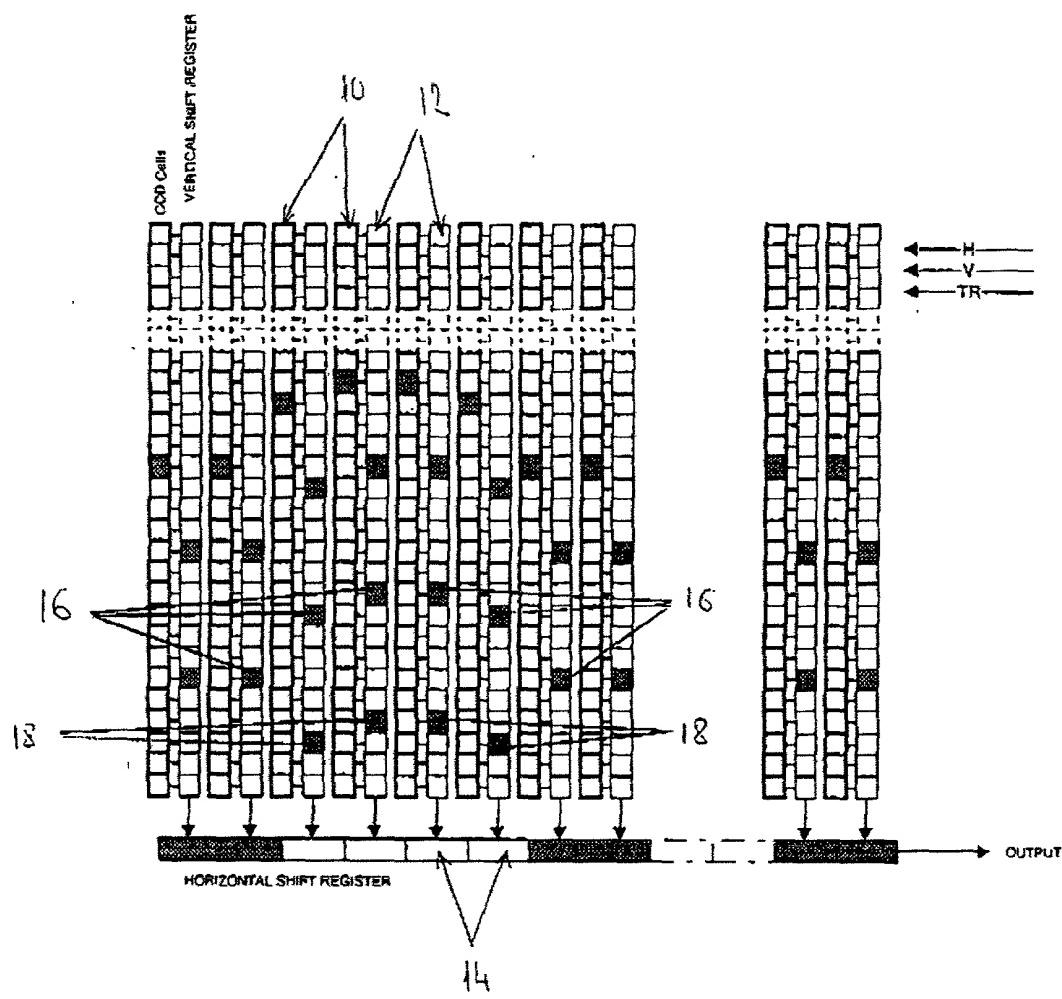


FIGURE 3

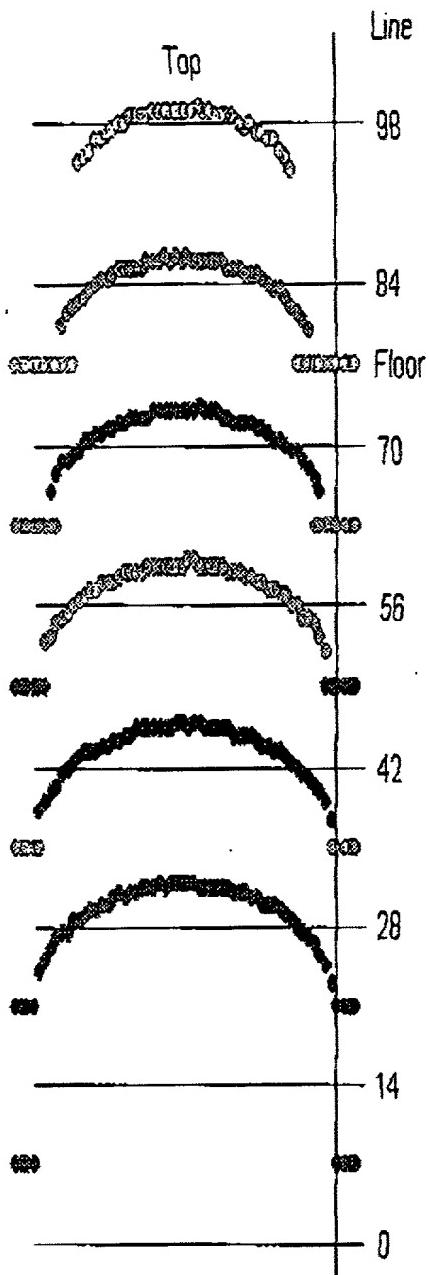
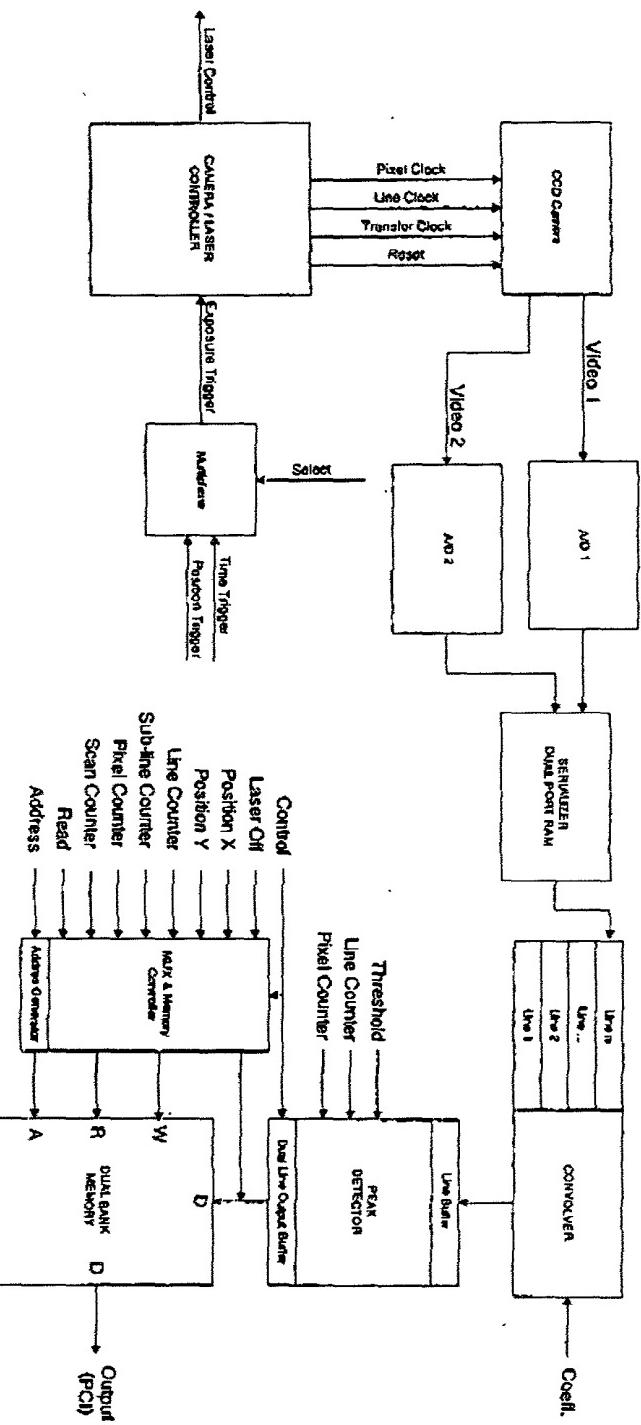


FIGURE 4

FIGURE 5

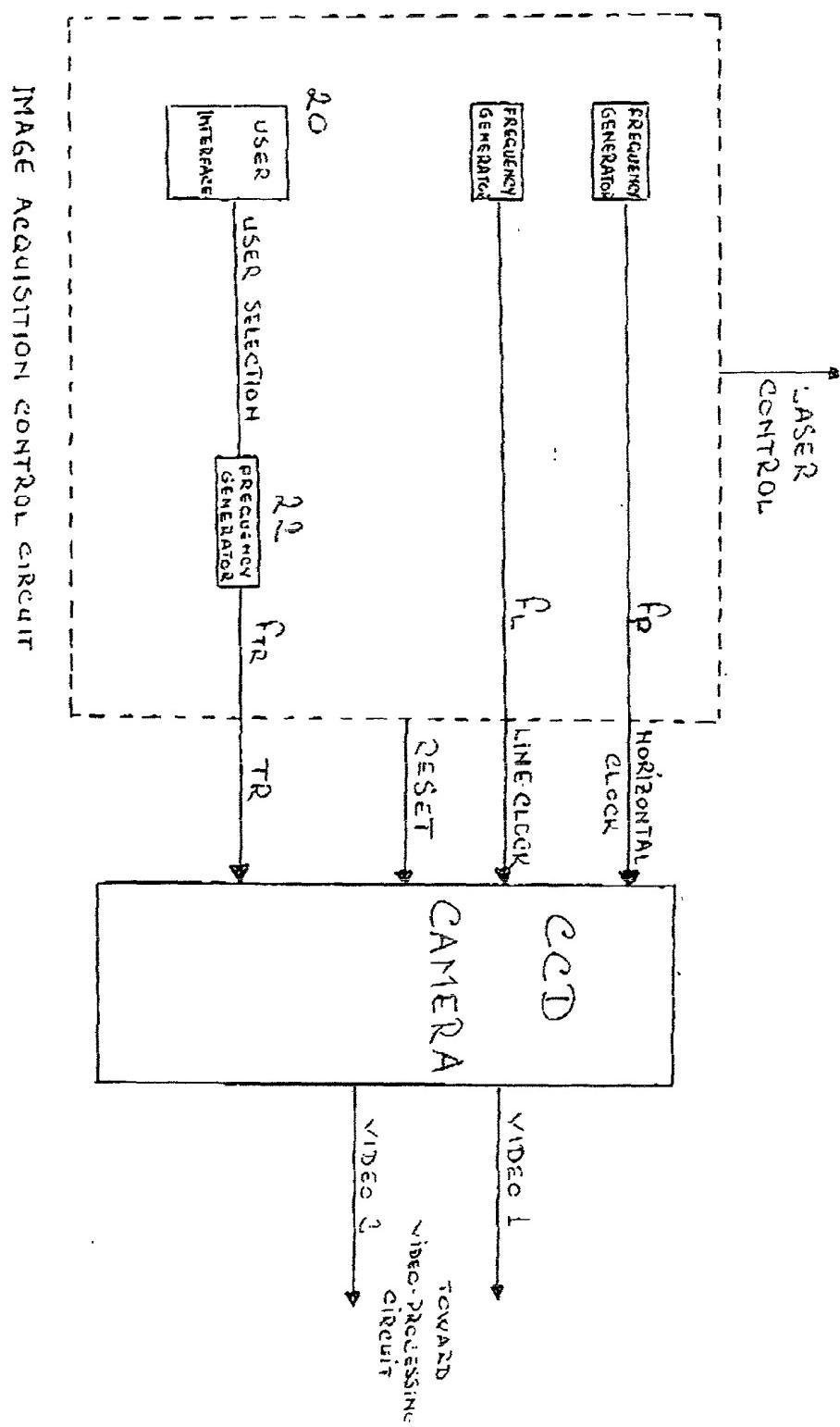


FIGURE 6

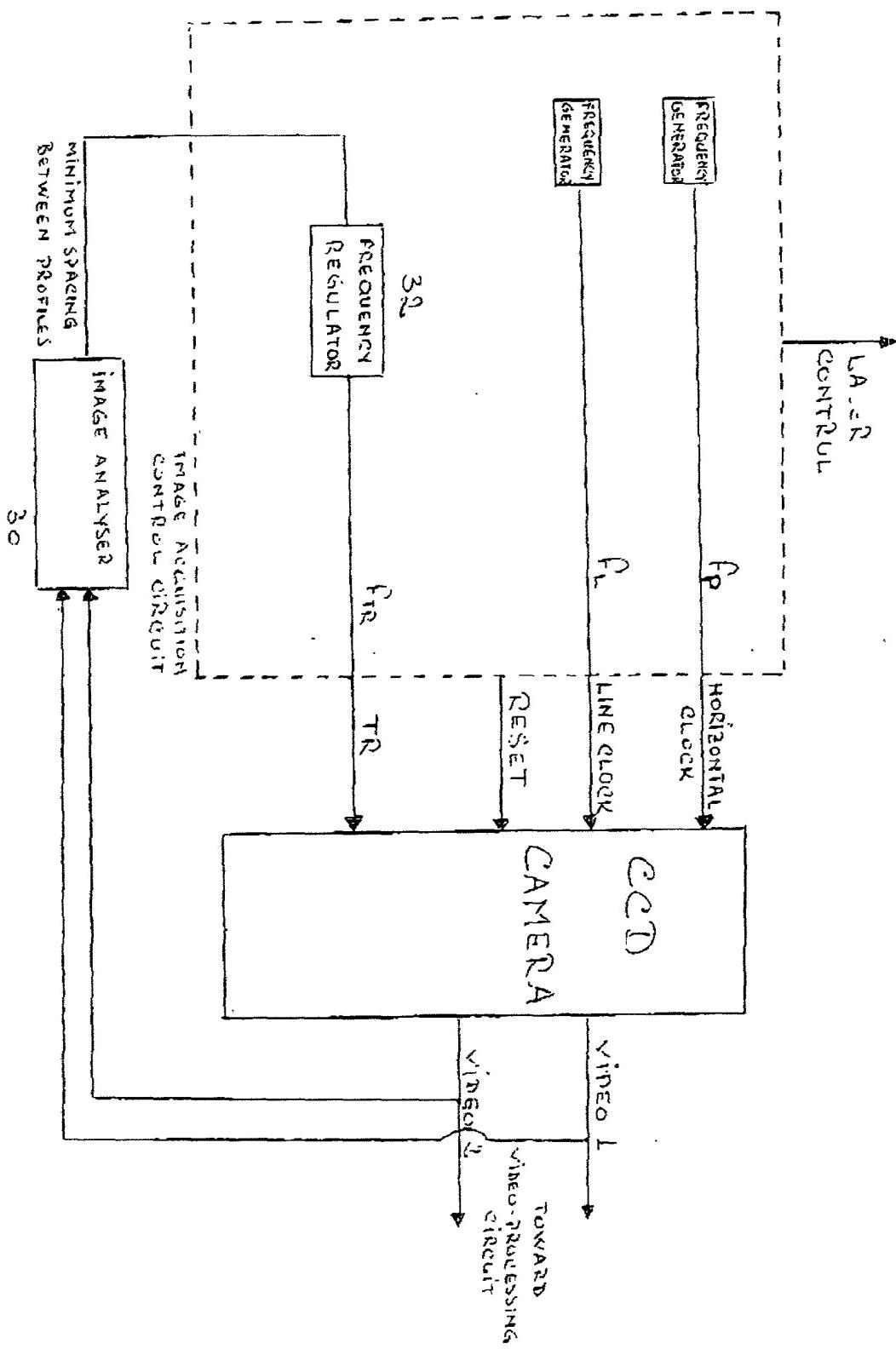


FIGURE 7

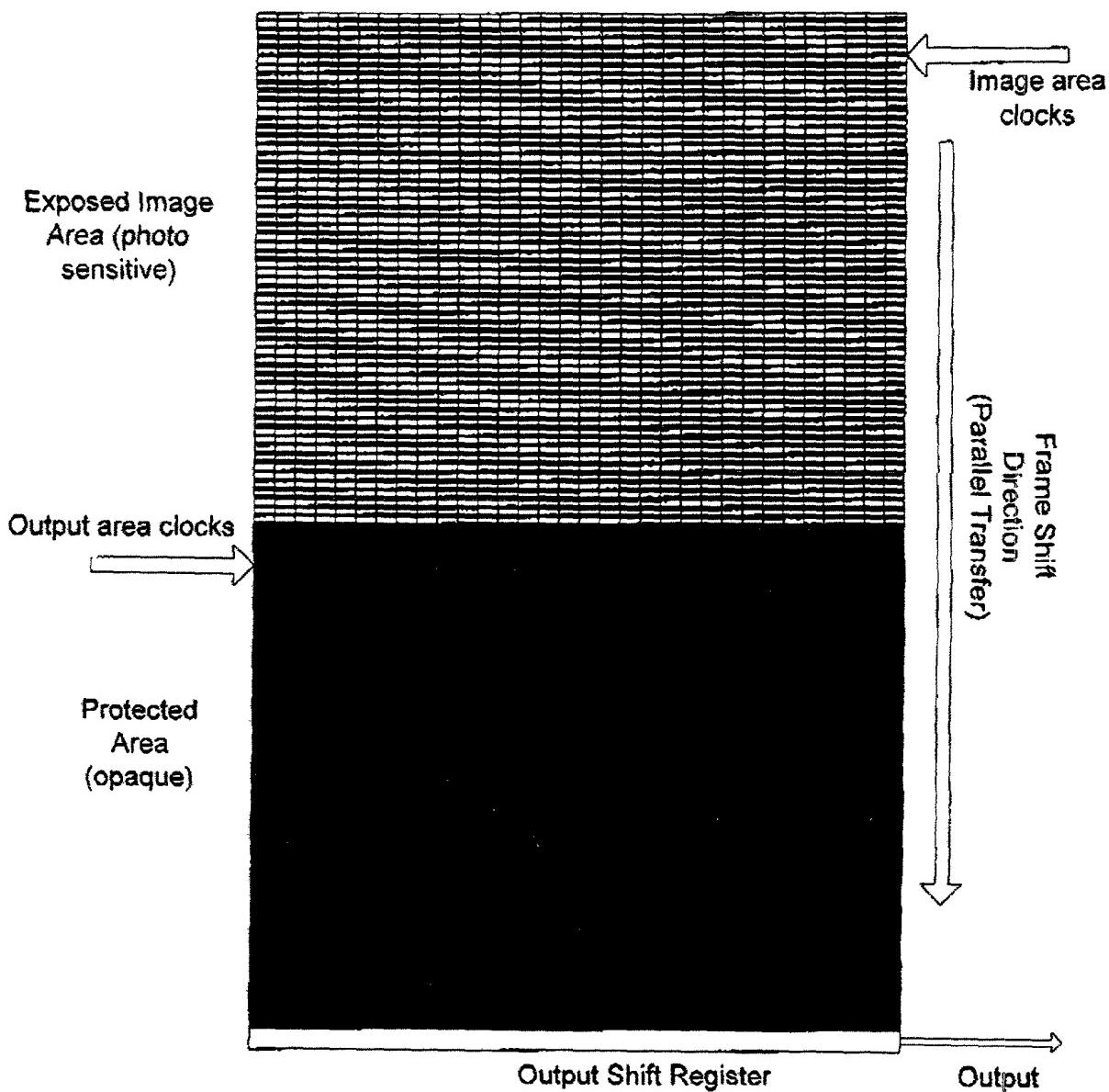


Fig. 8

Declaration and Power of Attorney for Patent Application

Déclaration et Pouvoir pour Demande de Brevet

French Language Declaration

En tant qu'inventeur ci-après désigné, je déclare par la présente que:

Mon domicile, mon adresse postale et ma nationalité sont tels que figurant ci-dessous à côté de mon nom.

Je crois être le premier inventeur original et unique (si un seul nom est mentionné ci-dessous), ou l'un des premiers co-inventeurs originaux (si plusieurs noms sont mentionnés ci-dessous) de l'objet revendiqué, pour lequel une demande de brevet a été déposée concernant l'invention intitulée

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

CCD IMAGING DEVICE FOR HIGH SPEED PROFILING

et dont le mémoire descriptif est ci-joint à moins que la case suivante n'ait été cochée:

- a été déposée le _____ sous le numéro de demande des États-Unis ou le numéro de demande internationale PCT _____ et modifiée le _____ (le cas échéant).

Je déclare par la présente avoir révisé et compris le contenu du mémoire descriptif ci-dessus mentionné, incluant les revendications, telles que modifiées par toute modification ci-dessus mentionnée.

Je reconnais devoir divulguer toute information pertinente à la brevetabilité, tel que défini dans le Titre 37, §1.56 du Code fédéral des réglementations.

Je revendique par la présente la priorité étrangère, en vertu du Titre 35, §§119(a)-(d) ou §365(b) du Code des États-Unis, sur toute demande étrangère de brevet ou certificat d'inventeur ou, en vertu du Titre 35, §365(a) du même Code, sur toute demande internationale PCT désignant au moins un pays autre que les États-Unis et figurant ci-dessous et, en cochant la case, j'ai aussi indiqué ci-dessous toute demande étrangère de brevet, tout certificat d'inventeur ou toute demande internationale PCT

the specification of which is attached hereto unless the following box is checked:

- was filed on _____ as United States Application Number or PCT International Application Number _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations., §1.56.

I hereby claim foreign priority under Title 35, United States Code, §119(a)-(d) or §365 (b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT International application which designated at least one country other than the United States, listed below, and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application

French Language Declaration

ayant une date de dépôt précédant celle de la demande à propos de laquelle une priorité est revendiquée.

on which priority is claimed.

Prior foreign application(s)

Demande(s) de brevet antérieure(s)

Priority Not Claimed

Droit de priorité non revendiqué

(Number) (Numéro)	(Country) (Pays)
----------------------	---------------------

(Day/Month/Year Filed) (Jour/Mois/Année de dépôt)
--



(Number) (Numéro)	(Country) (Pays)
----------------------	---------------------

(Day/Month/Year Filed) (Jour/Mois/Année de dépôt)
--



Je revendique par la présente tout bénéfice, en vertu du Titre 35, §119(e) du Code des États-Unis, de toute demande de brevet provisoire effectuée aux États-Unis et figurant ci-dessous.

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below.

(Application No./ N° de demande)

(Filing Date/ Date de dépôt)

(Application No./ N° de demande)

(Filing Date/ Date de dépôt)

Je revendique par la présente tout bénéfice, en vertu du Titre 35, §120 du Code des États-Unis, de toute demande de brevet effectuée aux États-Unis, ou en vertu du Titre 35, §365(c) du même Code, de toute demande internationale PCT désignant les États-Unis et figurant ci-dessous et, dans la mesure où l'objet de chacune des revendications de cette demande de brevet n'est pas divulgué dans la demande antérieure américaine ou internationale PCT, en vertu des dispositions du premier paragraphe du Titre 35, §112 du Code des États-Unis, je reconnais devoir divulguer toute information pertinente à la brevetabilité, tel que défini dans le Titre 37, §1.56 du Code fédéral des réglementations, dont j'ai pu disposer entre la date de dépôt de la demande antérieure et la date de dépôt de la demande nationale ou internationale PCT de la présente demande:

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s), or §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

08/922,026
(Application No.)
(N° de demande)

Sept. 2, 1997
(Filing Date)
(Date de dépôt)

pending
(Status) (patented, pending, abandoned)
(Statut) (breveté, en cours d'examen, abandonné)

(Application No.)
(N° de demande)

(Filing Date)
(Date de dépôt)

(Status) (patented, pending, abandoned)
(Statut) (breveté, en cours d'examen, abandonné)

French Language Declaration

Je déclare que toute les déclarations faites dans la présente sont à ma connaissance, véridiques et que toutes les déclarations faites à partir de renseignements ou de suppositions sont tenues pour véridiques; et de plus, que toutes ces déclarations ont été faites en sachant que toute fausse déclaration volontaire ou son équivalent est passible d'une amende ou d'une peine d'emprisonnement, ou des deux, en vertu de la Section 1001 du Titre 18 du Code des États-Unis, et que de telles déclarations volontairement fausses risquent de compromettre la validité de la demande de brevet ou du brevet délivré à partir de celle-ci.

POUVOIR: En tant qu'inventeur désigné, Je nomme par la présente l'(les) avocat(s) et/ou agent(s) inclus sous le numéro de client officiel suivant, avec plein pouvoir de révocation et de substitution, chargés de poursuivre cette demande et de traiter toute affaire s'y rapportant avec l'Office des brevets et des marques: (*mentionner le nom et le numéro d'enregistrement*).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the agents and/or attorneys included in the following Customer Number, with full power of substitution, association, and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: (*list name and registration number*)

Please send all correspondence and direct all telephone calls to: / Veuillez adresser toute correspondance et tout appel téléphonique à:



020988

PATENT AND TRADEMARK OFFICE

Full name of sole or first inventor (Nom complet de l'unique ou premier inventeur)	Citizenship (Nationalité)	Date (dd/mm/yyyy) (jj/mm/aaaa)
Bojko VODANOVIC	Canadian	
Residence and Post Office address (Domicile et adresse postale)	Inventor's signature (signature de l'inventeur)	
86 Midland Avenue, Beaconsfield, Quebec, Canada, H9W 4P1		